Recently, there has been an increasing interest in developing lithium-titanium oxide (Li$_4$Ti$_5$O$_{12}$) materials of spinel (cubic) structure as a potential negative electrode (anode) in lithium-ion. Lithium-titanium oxide has good structural stability, with an almost negligible volume change during the Li$^+$ insertion and extraction processes, which suggests theoretically unlimited cycle life. On the other hand Li$_4$Ti$_5$O$_{12}$ is a wide band gap material ($E_g = 3.6$ eV), so pure, undoped crystals have very high electronic resistivity, of the order of $10^{12}$ $\Omega$cm. However, the strongly bound titanium oxide structure leaves place for diffusion of lithium ions.

The nanocrystalline Li$_4$Ti$_5$O$_{12}$ of nearly cubic spinel structure was synthesized by three-step solid state synthesis [1]. It was measured optically with use of Raman scattering, absorption and time-resolved photoluminescence (PL) and electrically: I-V characteristics and impedance spectroscopy.

Raman spectroscopy revealed differences between pristine and electrochemically charged samples showing that lithium can outdiffuse from the material. The delithiation of this compound caused the disappearance of a typical Li$_4$Ti$_5$O$_{12}$ spinel spectra and the new modes arrival which were located at 147, 192, 219, 330, 423, 519 and 631 cm$^{-1}$.

The PL spectra consisted of weak band-to-band emission at about 3.6 eV and strong deep defect band with peaks at 2.2 and 2.6 eV. The decays were of Langevin type what was due to carriers (electrons and holes) diffusion.

Impedance spectroscopy was measured in the range 1 Hz - 100 kHz. It was found (see Fig.) that in low frequency range the impedance was characteristic for electronic transport (constant $\text{Re}(Z)$, $\text{Im}(Z) = (i\omega C)^{-1}$), but in high frequencies ($f > 100$ Hz) signal was dominated by Warburg impedance ($\text{Re}(Z) = A_W \omega^{-1/2}$), what is due to lithium diffusion.

Measurements of conductivity in function of temperature revealed thermal activation with energy $E_A = 0.7$ eV. This activation energy is most probably related to diffusion of lithium through Li$_4$Ti$_5$O$_{12}$ lattice.

In conclusion, using optical and electrical methods we have observed transport in samples and determined diffusion parameters (Warburg constant, activation energy).